

ACTION SHEET No. 3

**The United States Department Of Energy (DOE)
and
The Commissariat à l'Energie Atomique of France (CEA)
for
Nuclear Materials Transportation Security**

1. INTRODUCTION

Pursuant to article 3 of the Agreement, signed on December 27, 1997, between DOE and CEA concerning research and development in the field of physical protection of nuclear materials, DOE and CEA (the Parties) undertake to carry out a cooperative effort on nuclear materials transportation security.

2. SCOPE OF WORK

This action sheet provides for collaboration between DOE and CEA in the area of nuclear materials transportation security. Specifically, it addresses physical protection of overland nuclear materials transportation (notably by road or by rail) against diversion and malevolent actions. Activities will include exchange of information, comparison of experimental data, and Research and Development (R & D) activities focused on issues related to enhancing nuclear material transportation security in the U.S. and France, and in understanding potential consequences of successful attacks. The work will be performed both in France and in the United States, as deemed most appropriate and cost effective. Each of the participants may invite other NATO nations involved in the International Workshop on Security of Nuclear Waste during Transport to participate in their efforts.

3. PROGRAM MANAGEMENT

Sandia National Laboratory (SNL) is responsible for providing analytical/experimental information on assessment of damage to surrogate spent fuel pellet configurations, and response of typical spent fuel cask designs to one or more types of High Energy Density Devices (HEDDs). These may include Conical Shaped Charges (CSC), platter charges (PC) and explosively formed projectiles (EFP). CEA is similarly responsible for CSCs only.

CEA will share results of code validation performed with SNL-supplied contamination data.

Specific tasks associated with this work are detailed in Appendix I. Appendix II identifies key personnel associated with this action sheet.

4. DESCRIPTION

This action sheet addresses DOE and CEA concerns regarding physical protection for overland transportation of nuclear material. The specific focus of activity will be on the potential effects of three types of explosives that might be employed by terrorists or other groups. Exchanging information about physical protection techniques and procedures, and conduct of experiments with various types of explosives will benefit both parties in their efforts to counter potential threats and to ameliorate the effects of explosive events should malevolent attempts be successful.


5. FINANCIAL MANAGEMENT

DOE and CEA shall bear their own expenses for this action sheet.

6. DURATION AND TERMINATION

This action sheet shall come into force upon the later date of signature, and shall continue in force for a two-year period according to the attached schedule. Extensions of this action sheet will require letter exchange by the parties specifying duration of the extension and activities remaining.

For the United States Department Of Energy
(DOE)

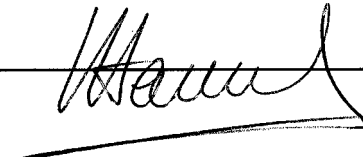
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Appendix I

Description of Tasks

I. OBJECTIVES

The objectives of this action sheet are to share DOE and CEA experience in the field of nuclear materials transportation security as it relates to issues regarding physical protection and malevolent actions, and to carry out joint exchange of information on R & D topics of common interest.

II. BACKGROUND

Concerning the physical protection of nuclear material transport, **IPSN** (Institut de Protection et de Sureté Nucleaire) has contributed to French development of a coherent set of regulations and an organizational structure allowing effective control of nuclear material transport. The underlying purpose of the development is to provide government authorities with means of checking the transport system for sensitive nuclear materials. The effectiveness and reliability of this inspection process results from a continuous application of inspection procedures to different aspects of the transportation system, including design, manufacture, operation, and maintenance of the transport system as well as the conditions under which individual journeys are carried out. Similar formal processes and regulatory schema are in place in the US to provide appropriate levels of protection of health and safety for US citizens against the potential risk from sabotage of spent fuel transportation and other relatively high hazard radioactive materials.

Concerning malevolent actions, significant work has been done in assessing the response of spent fuel casks, spent fuel, and spent fuel surrogates to the actions of High Energy Density Devices (HEDDs). Most recent has been the work at Sandia (Luna et al, 1999), in France (V. Roland, 1989, A. Nicaud and F. Delmaire-Sizes, 1999) and GRS in Germany (Pretzch et al, 1994). Earlier work at Sandia (Sandoval, 1982), INEL (Alvarez et al, 1983) and Battelle Columbus Labs (Schmidt et al, 1982 & 83) developed significant basic data on the phenomena involved. There has also been significant work at Sandia not in the open literature by Suber, Sandoval, Vigil, Bennett, Philbin and others.

Much of the work is related to a particular class of HEDD referred to as conical shaped charges (CSC). As a result it is generally believed that the threat from such devices is relatively well understood. However, there are HEDD types whose effects have been studied less extensively.

DOE proposes to perform exploratory evaluations of the effects of one or more other HEDD designs that include platter charges (PC) and explosively formed projectiles (EFP). These differ from CSCs primarily in mass of the penetrating material (larger) and the interaction velocity (smaller). CSC jets may be moving at 15 to 20 mm/ μ s while PCs and EFPs are in the 4 to 6 mm/ μ s.

Since the mass and frontal area of a PC (and to some extent an EFP) may be arbitrarily large, it is clear that the potential total energy deposition for these devices on a cask may be relatively larger than with a CSC, but the energy content per unit area is likely to be smaller or perhaps in the same range. This energy content together with a relatively large interaction area suggests that there needs to be some research effort expended in defining the type of damage that might be inflicted on casks of modern design by typical PC and EFP threats.

If larger penetrations of a cask by PCs and/or EFPs occur than by CSCs, then it would be appropriate to evaluate the amount of pellet rubble and respirable aerosol that might be produced, released and dispersed in the environment.

In the context of spent fuel cask attack, the major areas of uncertainty relating to PC and EFP effects compared to CSC's include:

- ability to penetrate cask walls as a function of HEDD design (mass, area and speed)
- relative penetrability of various cask wall designs
- efficiency of producing rubble, fines, and respirable aerosol from surrogate or actual spent fuel intercepted.

Because of physical protection devices installed on the French transportation, and in taking into account both the definition of the threats and the associated arms, IPSN is confident that PCs and EFPs are not a significant threat and thus will limit its own study to the CSC that are included in the three topics listed above. IPSN will especially focus on evaluation of the contamination that might be produced, released, and dispersed in the environment. A number of computer tools have been developed and may be applied to these studies. Results concerning the behavior of spent fuel casks attacked by the other kinds of HEDDs (i.e. PC and CSC), which have not yet been taken into account in the French studies will be considered chiefly as bibliographical references. However, IPSN is also interested in the behavior of fresh MOX (non-irradiated) nuclear material when attacked by terrorists during the transport of the material.

III. SCOPE

Concerning the physical protection of transport and taking into account the confidential aspects of data, collaboration will be limited initially to discussions and exchange of information. Topics that could be discussed concerning physical protection are the following:

- types of physical protection during transport and associated devices
- physical protection design for overland transport of nuclear material
- physical protection analysis (methodologies and inspections).

Concerning malevolent actions, an investigative program to explore the comparative effects of the three types of HEDDs will include analysis, sub-scale testing, and if feasible, full scale testing in a carefully staged program. Analysis and sub-scale testing will proceed in parallel while full scale testing, if indicated, will culminate the R&D effort.

The tasks outlined below suggest the overall structure of collaboration. Specific details and exact dates for project activities will be established once facilities have been identified.

IV. TASKS

CEA and DOE will exchange information on:

- national regulations
- types of transportation
- differential threat scenarios
- relevant R & D activities
- work methodologies
- protective measures related to protection against various HEDDs and concerning security of overland nuclear materials shipments against attempted theft, diversion or malevolent action.

Task 1 - Physical Protection

Topics of collaboration will include national transportation regulations and exchange of technical information about specific types of equipment. For example:

- evaluation of physical protection device performance,
- evaluation of computers for vehicle installation
- tests of electric and electronic compatibility
- tests of cartographic information systems
- data and voice transmission devices
- data encryption

Task 2 - Malevolent Actions

Sub-Task 2.1 - Analyses

This aspect of the program will include hydrodynamic calculation of the interaction of various wall and HEDD designs to estimate relative penetration capability. An analysis program may include:

1. Estimation of the energy density delivered by small scale HEDD's (consistent with experimental facility capability) to surrogate spent fuel materials in a closed system that will allow all particles and aerosols to be captured and characterized. The objective of the task is to define a set of scaled devices consistent with the goals of the experimental program and the facilities in which testing will occur. That is, the penetration needed to breach a wall and interaction with spent fuel simulant without compromising the integrity of the experimental apparatus and data that will be gathered. Since several modern spent fuel cask designs exist, the construction analyzed should be typical of those casks and include monolithic steel, and layered designs incorporating stainless steel, DU, and plastic neutron shield materials in 1/3 to 1/4 scale or, perhaps, smaller scale as appropriate.
2. Estimation of the effects of several full-scale HEDD's (of existing weaponry or plausible threats) with full-scale spent fuel casks. These should emphasize estimation of the energy density to spent fuel pins and the total amount of fuel impacted.

Sub-Task 2.2 - Sub-Scale Experiments

The **goal** of these experiments is to obtain sufficient data to test the reliability and validity of the analyses and to obtain specific data on which consequence analyses may be based. It is assumed that most experiments will be conducted in a closed experimental apparatus that enables accounting for all materials used and produced in the testing program. Similarly, it is assumed that the set of HEDDs used in all testing will be identical or that the sets used will have a single scale factor linking the designs. The experimental program will contain the following elements:

1. Interaction of CSC's (IPSN and DOE) PC's and EFP's (DOE only) having measured speed and mass with single spent fuel rod simulants in order to determine relative production of rubble, fines and aerosols in the same basic experimental apparatus.
2. Interaction of CSC (IPSN and DOE), PC and EFP (DOE only), having measured speed and mass with single real spent fuel pellets in order to determine relative production of rubble, fines and aerosols in the same basic experimental apparatus.

3. Impacting scale model casks containing the surrogate fuel used above with representatively scaled HEDD's to determine penetration ability, rubble, fines and aerosol production from the surrogate material. In addition, the amount of fuel simulants exiting the cask will be measured to compare with earlier experiments,

Sub-Task 2.3 - Full Scale Experiments

These tests will be the equivalent of an admiral's test for the program as a whole to demonstrate that physical principles defined in the analysis and test programs are sufficiently well understood to allow extrapolation to a meaningful scale. Such an extrapolation will enable experimenters to gauge the effects of potential sabotage acts. It would be preferable to conduct the test in a fully closed apparatus with real spent fuel rods, but it is recognized that such experiments are likely to be beyond the financial resources of the participants. If an experiment with spent fuel is not possible, surrogate fuel could be used, but in either case with effective means of measuring the HEDD penetration, interaction with fuel surrogates, and escape of surrogate fuel materials.

IPSN does not intend to perform tests using real spent fuel assemblies, Nevertheless, IPSN is interested to use these results to validate the codes allowing the evaluation of the external contamination.

Task 3 – Project Report

SNL and IPSN will collaborate in producing a report that documents the results of the analyses and experiments conducted under this action sheet. The report will be made available to the appropriate CEA and DOE sponsors.

IV. PROJECT SCHEDULE

<u>Task</u>	<u>Duration</u>
Facility selection	Month 1
Initial Interactions	Months 1-4 (depending on mode of interaction)
Physical Protection Information Exchange	Months 1-12
Task 2 Malevolent Actions	
Sub-Task 2.1 - Analysis	Months 3 - 8
Sub-Task 2.2 – Sub-Scale Experiments (Assuming use of simulant fuels only)	Months 6 – 12
Sub-Task 2.3 – Full Scale Experiments (Assuming adequate funding)	Months 12 – 22
Task 3 – Project Report	Months 22 - 24

Appendix II

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